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PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

A REPORT ON THE FIFTH INTERNATIONAL SYMPOSIUM ON PLECOPTERA

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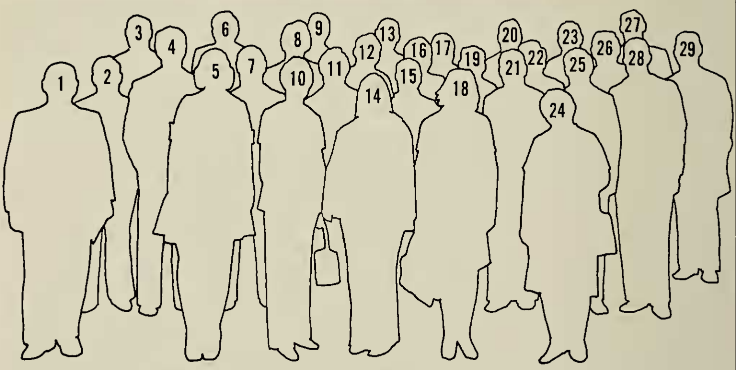
The first international Plecoptera symposium to be held in the new world took place September 3–6, 1974, in Washington, D.C. The four previous meetings were all in Europe (Switzerland, 1956, Austria, 1960, Germany, 1963, and Sweden, 1968) therefore, this meeting provided an excellent opportunity for American and European scientists to become better acquainted and exchange information on current research.

The symposium was sponsored by the Smithsonian Institution with the aid of the Office of Academic Affairs and the Department of Entomology. The international committee consisted of: R. W. Baumann, Smithsonian Institution, Washington, D.C., USA, Organizing Chairman; J. Illies, Max-Planck Limnology Institute, Schlitz, West Germany, Honorary Chairman; C. G. Froehlich, University of São Paulo, São Paulo, Brazil; P. P. Harper, University of Montreal, Montreal, Quebec, Canada; T. Kawai, Nara Women's University, Nara, Japan; A. Lillehammer, University of Oslo, Oslo, Norway; I. D. McLellan, Westport, New Zealand; K. W. Stewart, North Texas State University, Denton, Texas, USA; P. Zwick, Max-Planck Limnology Institute, Schlitz, West Germany.

Meetings were held during the days of September 3–5 in the Carmichael Auditorium of the Smithsonian Institution, National Museum of History and Technology. The opening session on the morning of September 3 included a welcome by the chairman and greetings by local dignitaries and was



1. R. W. Baumann
2. P. J. Spangler
3. K. W. Stewart
4. S. B. Fiance
5. R. F. Surdick
6. D. D. Zeigler
7. M. A. Tkac, Jr.
8. K. W. Bode
9. H. W. Woolman, III
10. V. R. Tolbert
11. S. W. Szczytko
12. O. S. Flint, Jr.
13. R. Rupprecht
14. D. R. Smrchek
15. N. N. Kapoor
16. P. P. Harper
17. C. H. Nelson
18. D. Kacanski
19. P. Zwick
20. J. Illies
21. I. D. McLellan
22. T. Kawai
23. E. F. Benfield
24. M. Kohno
25. J. V. Smolka
26. W. E. Ricker
27. B. R. Oblad
28. E. P. McElravy
29. B. P. Stark

FIG. 1. Group picture in front of Museum of History and Technology.

highlighted by an invitational lecture by Professor Dr. Joachim Illies entitled, "The Status of Plecoptera Research Today." Professor Illies recounted the history of plecopterology and ended by noting that although much has been accomplished, there is still a lot to learn about all aspects of Plecoptera.

Fig. 2. Symposium participants, left to right: Peter Zwick, Joachim Illies and Dragica Kaćanski.

Fig. 3. Portion of symposium audience during presentation of a paper.

Fig. 4. Field trip, left to right: Ian D. McLellan, Paul J. Spangler, Henry W. Woolman, III.

The submitted papers were organized into five groups according to content and were presented as listed below:

Tuesday, September 3, 1974 (Afternoon)

Section leader: K. W. Stewart, Texas, USA.

Basic Principles and Practices in Zoological Nomenclature,
by C. W. Sabrosky, Washington, D.C., USA.

The Phylogenetic System of the Order Plecoptera,
by P. Zwick, Schlitz, Germany.

Notes on Nomenclature and Taxonomic Growth of the Plecoptera,
by G. C. Steyskal, Washington, D.C., USA.

Numerical Taxonomic Analysis of Relationships in Plecoptera.
by C. H. Nelson, Tennessee, USA.

Scientific Illustration-Techniques and Media.
by G. L. Venable and M. Druckenbrod, Washington, D.C., USA.

FIG. 5. Field trip, left to right: Rebecca F. Surdick, Oliver S. Flint, Jr., Briant R. Oblad.

Wednesday, September 4, 1974 (Morning)

Section leader: P. P. Harper, Montreal, Canada.

Notes on the Nearctic Genera of Perlidae.
by B. P. Stark, Utah, USA.

The *Isoperla* of Texas.
by S. W. Szczytko, Texas, USA.

Notonemouridae-Systematics and Distribution.
by J. Illies, Schlitz, Germany.

The Family Nemouridae.
by R. W. Baumann, Washington, D.C., USA.

African Species of the Genus *Neoperla* Needham (Perlidae).
by P. Zwick, Schlitz, Germany.

(Afternoon)

Section leader: C. H. Nelson, Tennessee, USA.

Mating Behavior of *Paragnetina fumosa*, *Perlinella drymo* and *Hydroperla crosbyi*; with Special Emphasis on External Sperm Transfer in *H. crosbyi* (film).
by K. W. Stewart, Texas, USA.

An Emergence Sequence of Chloroperlidae in a Northeastern Ohio Stream.
by M. A. Tkac, Jr., Ohio, USA.

Emergence Patterns in Plecoptera.
by P. P. Harper, Montreal, Canada.

The Structure (Ultra) and Function of the Ventral Lobe and the Hammer of Plecoptera.
by R. Rupprecht, Mainz, Germany.

Thursday, September 5, 1974 (Morning)

Section leader: P. Zwick, Schlitz, Germany.

The Stoneflies (Plecoptera) of the Rocky Mountains.
by A. R. Gaufin, Utah, USA.

Preliminary Studies on Pennsylvania Stoneflies.
by R. F. Surdick, Pennsylvania, USA.

Biogeography of New Zealand Plecoptera.
by I. D. McLellan, Westport, New Zealand.

A Preliminary Report of the Plecoptera Fauna in Bosnia and Herzegovina (Yugoslavia).
by D. Kaćanski, Sarajevo, Yugloslavia.*

(Afternoon)

Section leader: I. D. McLellan, Westport, New Zealand.

Autohemorrhage in Two Stoneflies and its Effectiveness as a Defense Mechanism.
by E. F. Benfield, Virginia, USA.

Some Morphological Features of Gills in Plecoptera.
by N. N. Kapoor, Montreal, Canada.

Notes on the Family Scopuridae.
by T. Kawai, Nara, Japan.

Distribution of Stoneflies (Plecoptera) Within the Hubbard Brook Watershed, New Hampshire.
by S. M. Fiance, New York, USA.

During the extra time made available, because some participants could not attend, some very interesting extemporaneous presentations were given. William E. Ricker explained the derivations of many of the names that he has proposed for Plecoptera genera and species. Joachim Illies showed films of the two most recent Plecoptera meetings

* Paper not given at this time but abstract included.

in Germany and Sweden and presented the results of his emergence control studies on Breitenbach.

Those in attendance on September 3 were recorded in the group picture. Everyone that attended the symposium and registered is listed at the end of this report along with their current address.

The first issue of the plecopterists newsletter *Perla* was distributed and all felt that it was a positive step forward. Plans were made to continue the newsletter at approximately one-year intervals.

A Plecopterists Luncheon was held in the Commons Room of the original Smithsonian Building on September 4 where all present were able to mingle and make new friends. The ladies in attendance at the Symposium were able to participate in an excellent program organized by Carol M. Flint.

The final day, September 6, was the field trip led by Dr. Oliver S. Flint, Jr., to the Bull Run Mountains in Northern Virginia. Although it rained most of the day and the interest of some was dampened, most everyone experienced a day to remember.

One of the major objectives of this symposium was to bring together young plecopterists to meet and learn directly from the established experts in the field. This was realized because approximately one-third of the participants were students and the open forum type of discussion allowed for free interchange of ideas. After hours contact was made difficult because of the housing arrangements available but hopefully this will be corrected in the next symposium tentatively scheduled to be held in Schlitz, West Germany.

Abstracts of Presented Papers

BASIC PRINCIPLES AND PRACTICES IN ZOOLOGICAL NOMENCLATURE.

BY CURTIS W. SABROSKY, *Systematic Entomology Laboratory, U.S. Department of Agriculture, Washington, D.C.*

The history of successive international codes of zoological nomenclature was briefly reviewed, from the first in 1905 (then called the Règles, or Rules) to the 1961 and 1964 editions of the Code, to changes made at Monaco in 1972 and at Ustaoset in Norway in 1973. An Editorial Committee is now working on a 3rd edition that will, hopefully, be ready for final approval in late 1976.

Basic principles were listed and discussed briefly:

1. The Priniciple of Availability
2. The Principle ("Law") of Priority (with Conservation a Limitation on Priority)
3. The Language of Scientific Names
4. The Principle of Coordination
5. The Principle ("Law") of Homonymy
6. The Principle of Typification

Terminology: Definitions or explanations were offered for certain nomenclatural jargon: nominal genus, junior and senior, objective and subjective, primary and secondary.

A few "do's" and "don't's" that would help in avoiding nomenclatural difficulties and expedite taxonomic work were suggested.

THE PHYLOGENETIC SYSTEM OF THE ORDER PLECOPTERA.

BY PETER ZWICK, *Limnologische Flußstation des Max-Planck-Instituts für Limnologie, Germany.*

Animals can be classified in many ways, to serve many purposes and these systems may be altered or abandoned, according to the needs of their users. However, taxonomy is then reduced to a subordinate mean, a file for other disciplines and such taxonomy cannot assist in scientific research.

A more adequate way to treat taxonomy or systematics is as a science of its own, equal in rank to other sciences, with rules and procedures following scientific logic, and nothing else. Under no circumstances may these rules be bent or modified to suit other demands. The aim of such scientific taxonomy is establishment of the one system which evolved in time. Scientific taxonomy attempts to elucidate the genealogical relationships between species and supraspecific taxa of a given time, in the present or in the past. These relationships are represented in unmistakable ways, either in written systems or in cladograms. Each of these two representations can be transformed into the other, without ambiguity or loss of information. Strict monophyly of supraspecific taxa is mandatory, paraphyletic or polyphyletic taxa are not admitted. Such a system has been termed phylogenetic by Hennig (1949).

A brief account of the principles of phylogenetic systematics has been given in English by Hennig (1965). Brundin has also extensively dealt with it several times, e.g. 1966. For those who are critical of the theory of phylogenetic systematics it would be important to know its recent formulation by Schlee (1971), which is without some of the corollaries that have at times been taken to be essentials of the theory.

Unfortunately, the former "evolutionary taxonomists" have started to use the term phylogenetic systematics for their classifications. They even try to refuse the use of the term according to its older definition by Hennig. This is unfortunate, because phylogenetic systems of evolutionary taxonomists lack a clear concept. They are mixtures of "science, most strictly speaking, and of an art" (Simpson, 1961). Therefore, these systems are equivocal and are in fact little more than the usual intuitive taxonomy with evolutionary flavouring, unsuited for scientific work.

The phylogenetic system of Plecoptera (in the sense of Hennig) shown below (Fig. 6), was briefly discussed (for details see Zwick, 1973).

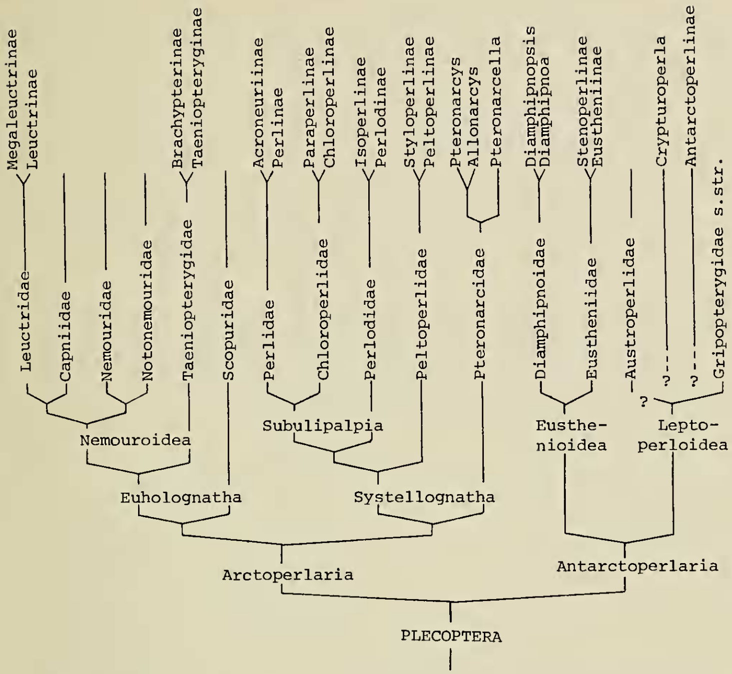


FIG. 6. The phylogenetic system of Plecoptera (from Zwick, 1969, modified).

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NOTES ON THE NOMENCLATURE AND TAXONOMIC GROWTH OF THE PLECOPTERA.

BY GEORGE C. STEYSKAL, *Systematic Entomology Laboratory, IIBIII, Agr. Res. Serv., USDA, c/o National Museum of Natural History, Washington, D.C.*

Students of the Plecoptera are fortunate in having up-to-date catalogues and a systematic compendium of the order in the works of Illies (1966) and Zwick (1973). The literature of few orders of insects is so well indexed and the classification so well revised by the most modern methods.

Order and Suborder	Group	Superfamily	Family
Plecoptera			
Antarctoperlaria		Eusthenioidea	Eustheniidae Diamphipnoidae
		Gripopterygoidea (Leptoperloidea)	Austroperlidae Gripopterygidae Gripopteryginae Leptoperlinae Paragripopteryginae Antarctoperlinae
Arctoperlaria	Systellognatha	(Pteronarcyoidea)	Pteronarcyidae
		(Peltoperloidea)	Peltoperlidae
		Perloidea (Subulipalpia)	Perlodidae Perlidae Chloroperlidae
	Euholognatha	Scopuroidea	Scopuridae
		Nemouroidea	Taeniopterygidae Notonemouridae Nemouridae Capniidae Leuctridae

The "Argumentationschema" on p. 2 and the dendrogram on p. 16 of the work by Zwick are to some extent at variance with the classification followed in the catalogue and the systematic index, which is as shown above. The genus *Crypturoperla* is shown in the Schema as of equal rank with the Austroperlidae, but in the catalogue and the systematic index the genus is treated as a member of that family. The Antarctoperlinae are treated in the Schema as of equal rank with the

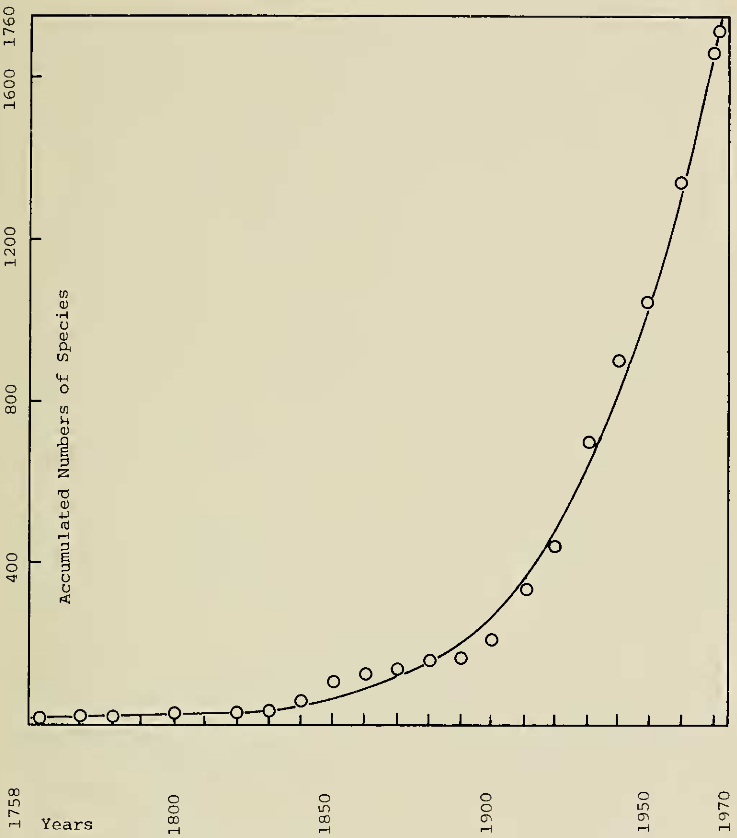

Fig. 7. Taxonomic growth curve of Plecoptera.

families Austroperlidae and Gripopterygidae, while in the catalogue the subfamily is placed under the Gripopterygidae.

The nomenclature of superfamilies in the foregoing chart has been made consistent by the replacement of the names Leptoperloidea and Subulipalpia by names based on those of the oldest included families, Gripopterygidae and Perlidae, respectively.

Inasmuch as the genitive of the Greek word ἀρκυς is ἀρκυος, which in classical Latin transcription is *arcyis*, the stem of *Pteronarcys* is *pteronarcy-* and the family-group names based thereupon should be Pteronarcyidae and Pteronarcyoidea.

A few corrections of gender of species-group names should be noted: *Desmoneura pulchellum* should be *D. pulchella.*

Dictyogenus and *Isogenus* should be neuter, inasmuch as the word genus is of that gender in both Latin and Greek (γενος). Two species-names should therefore be *Dictyogenus alpinum* and *D. ventrale*.

Etrocorema is neuter; the species-name should be *nigrogeniculatum*.

Perlinodes and *Perlodes* should be masculine according to Art. 30.a.ii (examples) of the Code; the names of 4 species should be *Perlinodes aureus, Perlodes frisonanus, P. intricatus*, and *P. jurassicus*.

Pseudomegarcys japonicus should be *P. japonica*.

Taenionema should be neuter: *T. californicum, T. frigidum, T. nigripenne, T. oregonense, T. pacificum, T. pallidum, T. raynorium, T. vanduzeeum*.

The generic name *Apteryoperla* is a strange formation. It probably should have been *Apterygoperla*, but there is no justification under the Code for emending it. A similar condition prevails in regard to the species-name of *Trinotoperla woodwardy*; emendation to *woodwardi* cannot strictly be justified.

A compilation of the dates of original description of the presently recognized species of Plecoptera may be charted as shown in Figure 7. For similar charts of other groups and discussion, see Steyskal (1965, 1967, 1973) and Vecht (1973). The sharply rising curve, with no indication of reversal, indicates that the order is about half known. About as many species as have already been named still await discovery and naming.

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NUMERICAL TAXONOMIC ANALYSIS OF RELATIONSHIPS IN PLECOPTERA.

by Charles H. Nelson, *Department of Biology, University of Tennessee, Chattanooga, Tennessee.*

The application of numerical taxonomic procedures for analyzing phyletic relationships within the Plecoptera is undertaken. In order to demonstrate the usefulness of these methods, 25 two-state and 13 multi-state characters were obtained from the species comprising the family Pteronarcidae. Quantitative phenetic procedures used to analyze these characteristics included the single-linkage cluster analysis, unweighted pair-group method using arithmetic averages (UMPGA), weighted pair-group method using arithmetic averages (WMPGA) and the function-point cluster method (FPCM). Quantitative cladistic procedures included the weighted invarient step strategy (WISS) and various methods for forming Wagner networks and trees. In addition, a Wagner network and several Wagner trees were constructed for the major taxonomic groups of the Plecoptera using data obtained from Zwick's (1973) study. The phenetic clustering techniques when applied to the pteronarcid data resulted in the identification of three principle clusters which agreed with the accepted classification of this family. In general, cladistic analyses agreed closely with those results obtained from using the classical method of Hennig, indicating that numerical cladistic procedures are consistent with the principles of "phylogenetic systematics".

SCIENTIFIC ILLUSTRATION-TECHNIQUES AND MEDIA.

BY GEORGE L. VENABLE AND L. MICHAEL DRUCKENBROD, *National Museum of Natural History, Smithsonian Institution, Washington, D.C.*

An introduction was given into the goals and functions of scientific illustration, and its' advantages over photography. The types of illustrations were discussed as were the equipment and media used in each. Step by step instruction was given for both line and tone illustrations, and various methods mentioned to enable the scientist to produce his/her own illusrations, both economically, and accurately.

NOTES ON THE NEARCTIC GENERA OF PERLIDAE.

BY BILL P. STARK, *Department of Biology, University of Utah, Salt Lake City, Utah.*

Each of seven Nearctic Acroneurine genera are characterized in terms of male tergal modifications, male hammer, male aedeagus, ovum, nymphal head and pronotum, and nymphal cerci. These data support Illies (1966) elevation of *Attaneuria, Beloneuria, Doroneuria, Eccoptura* and *Hesperoperla* to generic status, and the recent (Stark and Gaufin, 1974) removal of *Calineuria* from the synonymy of *Doroneuria.* The restricted definition of *Acroneuria* emphasizes the need for careful study of Oriental material currently placed in that genus.

The male aedeagus and female ovum are shown to have highly diagnostic characters for species recognition in *Acroneuria, Neoperla* and *Paragnetina.*

THE *ISOPERLA* OF TEXAS.

BY STAN W. SZCZYTKO, *Department of Biology, North Texas State University, Denton, Texas.*

The distribution of Plecoptera within the state of Texas was studied. Three species of *Isoperla* were found east of the Blackland Prairie, and specimens collected by J. A. and H. H. Ross in 1939 from El Paso were examined.

The four species consisted of *I. mohri* Frison 1935, two new species, and the El Paso specimens identified by Frison (1942) with some hesitation as *I. longiseta* Banks 1906, which appears to be a new species.

Collections of *Isoperla* from the adjacent states of Oklahoma and Louisiana were also examined. Six species were determined in all, including *I. clio, I. mohri, I. namata, I. longiseta* and what appears to be two new species.

The lacinia, mandibles, and labium were used for separating the nymphs, and the aedeagus and subgenital plate were used for separating males and females respectively.

NOTONEMOURIDAE—SYSTEMATICS AND DISTRIBUTION.

BY JOACHIM ILLIES, *Limnologische Flußstation des Max-Planck-Instituts für Limnologie, Germany.*

The taxonomy and distribution of the Notonemouridae are discussed with an emphasis on the fauna of the Australian region.

THE FAMILY NEMOURIDAE.

BY RICHARD W. BAUMANN, *Department of Entomology, Smithsonian Institution, Washington, D.C.*

The present taxonomic state of the family is reviewed at the generic level. The 13 recognized genera are characterized and the useful characters described and explained. A preliminary phylogenetic diagram is presented showing the basic relationships of the genera to each other in the famly Nemouridae. The distribution of the family is discussed and noted to be Holarctic and Oriental.

AFRICAN SPECIES OF THE GENUS *NEOPERLA* NEEDHAM (PERLIDAE).

BY PETER ZWICK, *Limnologische Flußstation des Max-Planck-Instituts für Limnologie, Germany.*

African *Neoperla* were supposed to belong to a single very variable species by Hynes (1952) and Illies (1966), who together synonymized

29 nominal species under one name. However, instead of the one and only *Neoperla spio* (Newman), there is a multitude of segregates. It has been shown before (Zwick, 1972, 1973), that these are not variants, but are specifically distinct. External genitalia, shape of penis and denticulation of the inner membranous sac need to be studied for reliable distinction of ♂♂. Shape and pattern of sternite 8, shape and denticulation of the vagina and receptacular base, and particularly the shape and structures of eggs provide specific characters in ♀♀. As genital characters alone are distinctive, it is easy to sort to species each sex separately, but it is not normally possible to associate sexes. This seriously hampers a revision of the African *Neoperla.*

Several species groups are distinguished, some were discussed in detail. It is as yet uncertain whether all morphological segregates are of specific or intraspecific rank. There are more than 10 species, possibly as many as 25 or even more. Most of them are very widely distributed in Africa.

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MATING BEHAVIOR OF *PARAGNETINA FUMOSA*, *PERLINELLA DRYMO* AND *HYDROPERLA CROSBYI*; WITH SPECIAL EMPHASIS ON EXTERNAL SPERM TRANSFER IN *H. CROSBYI.*

by Kenneth W. Stewart, *North Texas State University, Denton, Texas, USA.*

Virgin adult *Paragnetina fumosa* (Banks), *Perlinella drymo* (Newman) and *Hydroperla crosbyi* (Needham & Claassen) were paired in small plexiglass and glass chambers of various sizes. Super-8 mm cinema photographs and microscopic examination of mating pairs revealed species-specific variations in behavior in all 3 species, and an unreported method of external sperm transfer in *H. crosbyi.* Both males and females of *P. fumosa* and *P. drymo* engaged in drumming prior to mating. Capture involved a mere crawling onto the female by male *P. drymo,* but *P. fumosa* males assumed a distinctive "arched-body" posture during capture and an oblique "head-in-the-air" position during mating. Duration of copulation in both species was ca. 1 hr.

Neither sex of *H. crosbyi* drummed; the male crawled onto the female, assuming a typical superposition, then curved his abdomen around either the left or right side to engage the female subgenital plate with his genital hooks. The subgenital plate was pulled down and action by the accessory external genitalia, primarily the epiproct, resulted in formation of a depression or "sperm pocket" beneath it. Then followed a spontaneous eversion of the membranous male aedeagus, transfer of the sperm mass to the pre-formed "pocket," retraction of the aedeagus, and finally a curious tapping or brushing action by the male cerci on the female cerci. The latter served as a releaser for initiating telescoping contractions of the apical female abdominal segments, resulting in sperm aspiration. Sperm transfer was therefore external, with no copulation. All three species were polygamous.

AN EMERGENCE SEQUENCE OF CHLOROPERLIDAE IN A NORTHEASTERN OHIO STREAM.

BY MARTIN A. TKAC, JR., *Department of Biological Sciences, Kent State University, Kent, Ohio.*

The family Chloroperlidae is well represented in a small isolated stream habitat in northeastern Ohio. This stream flows through a unique, vertical-walled habitat within a dense mixed forest of northern hardwoods and hemlock. The gorge, Stebbins Gulch, has been incised into sandstones and shales to a depth in excess of three hundred feet, creating a relict habitat that is quite different from other stream habitats in northeastern Ohio.

Chloroperlidae present in this stream habitat include three genera and some five species. The species present and emergent periods are: *Alloperla caudata* Frison, May 27–July 29; *A. chloris* Frison, June 18–August 24; *A. imbecilla* (Say), May 20–June 4; *Hastaperla brevis* (Banks), May 20–July 1; and *Sweltsa onkos* (Ricker), May 20-June 18. Thus emergence commences with three species representing all three genera present in the area by May 20 and continues uninterruptedly until as late as August 24, with *Alloperla chloris* terminating the emergence of the family from the stream.

EMERGENCE PATTERNS IN PLECOPTERA.

BY PETER P. HARPER, *Départment des Sciences Biologiques, Université de Montréal, Québec, Canada.*

Emergence patterns in Plecoptera are discussed on the basis of data collected in 1972–1974 on the L'Achigan River in Quebec. Fifty emergence trap series were analysed from twenty-eight sites on the mainstream and from seventeen sites on six tributary streams.

Because of the relatively long adult life span of stoneflies, only data from emergence traps (or other means of collecting teneral adults) can be used to draw emergence patterns. General collecting and light-trap catches provide a biased picture of the emergence.

Emergence sequence indicates some temporal spacing between species, but closely related species often emerge at the same time and in the same places.

Emergence patterns for a given species are similar from year to year; the differences observed seem to be related to particular climatic conditions.

The emergence is alike in adjacent sites and is affected in a similar manner by the short-term climatic variations.

Two types of patterns can be distinguished, viz a short synchronous emergence and a longer gradual emergence. Though these are often easily separable, it is not yet clear whether they represent a basic characteristic of the species concerned or whether they are imposed by local climatic conditions. More data from various climatic regions is needed before this can be determined.

The numbers of species and specimens collected in the traps vary considerably from site to site and from year to year; this is probably explained by the great heterogeneity of the stream studied.

THE STRUCTURE (ULTRA) AND FUNCTION OF THE VENTRAL LOBE AND THE HAMMER OF PLECOPTERA.

BY RAINER RUPPRECHT, *Zoological Institute, Johannes Gutenberg University, Mainz, Germany.*

The fine structure of the vesicle of *Leuctra* and *Capnia* and of the hammer of *Isoperla* are described. There are bristles on the vesicle and beyond the edge of the hammer, which are innervated by a single bipolar sensory cell. The existence of a tubular body in the outer dendritic segment shows that this hair is mechano-receptive. The functions of these organs are understood by observation during use and by elimination of the hair on these organs. The vesicle (or ventral lobe) is a sternal protrusion covered with hair, giving the animal a feedback that it has touched the ground, and permitting it to conrol the drumming position. It is a tactile organ. The hammer is a protrusion or extension of one or more sterna (7 to 9), which is used for tapping. It is covered by hair which has the same function as the hair on the vesicle. The hammer is a tapping organ.

THE STONEFLIES (PLECOPTERA) OF THE ROCKY MOUNTAINS.

BY ARDEN R. GAUFIN, *Department of Biology, University of Utah, Salt Lake City, Utah.*

During the last 20 years the author and his associates at the University of Utah, and University of Montana Biological Station have conducted numerous studies to determine the taxonomy distribution, and ecology of the stoneflies of the Rocky Mountains of western North America.

The Rocky Mountains can be divided into two fairly well defined zones. The Northern Rocky Mountain zone includes the higher areas of British Columbia and Alberta, Canada, most of Montana, central Idaho, and the northwestern part of Wyoming. The extreme eastern section of Oregon and southeast Washington can also be included in this area and it contains typical Rocky Mountain species. The Southern Rocky Mountains are divided by the Colorado River, and associated high arid plateau areas, into the Wasatch area and the Colorado Rockies. The Wasatch area includes the Wasatch and Uinta Mountains of northern Utah, the Wasatch Plateau and other mountains of south central Utah, and the Green River drainage of southwest Wyoming. The Southern Rocky Mountain zone as such includes the mountains of south central Wyoming, all the mountains of Colorado, the mountains of New Mexico, and the mountains of Arizona.

The lowlands of the western states constitute distinct barriers to stonefly dispersal. The lack of cool clean streams in the lowlands presents barriers that have isolated many forms. Mountain ranges are the main routes of dispersal for the different groups. The two great barriers to movement are the Great Plains and the Great Basin. The Great Plains have completely blocked the eastern movement of the family Capniidae. The few western *Capnia* that are found in the Northeast have presumably dispersed across northern Canada, possibly during the cooler glacial periods. Several smaller barriers are the Snake River Plains area of the Columbia Plateau; the Colorado River, and the lowlands of eastern Washington, Oregon, and Nevada. The zones isolated by these barriers are usually mountain ranges or elevated areas with abundant precipitation.

Distribution of Stoneflies in Rocky Mountains

One of the principal objectives of the research that has been conducted has been to assemble data for a publication entitled, "The Stoneflies (Plecoptera) of the Rocky Mountains." It will include descriptions, keys, illustrations, and ecological data for the various species of stoneflies found in the region. It is anticipated that this bulletin will be ready for publication within the next year.

During the course of the research, records or specimens of 165 species of stoneflies from the Rocky Mountains have been collected (Table 1). Of these the most common families have been the Capniidae represented by 47 species, Chloroperlidae, 28 species, and Nemouridae, 24 species.

Montana and Idaho have yielded the most species with 119 and 101 species respectively. This may partly reflect the more intensive collecting that has been done in Montana particularly.

Of the 165 species, two, *Hesperoperla pacifica* and *Malenka californica*, have been collected in all ten of the provinces or states col-

TABLE 1. Stoneflies of the Rocky Mountains.

Family	No. Genera	No. Species
Pteronarcidae	2	5
Peltoperlidae	1	2
Perlodinae	10	18
Isoperlinae	1	14
Perlidae	8	9
Chloroperlidae	8	28
Taeniopterygidae	4	7
Nemouridae	9	24
Capniidae	6	47
Leuctridae	4	11
	53	165

lected. An additional six species, *Pteronarcella badia*, *Isogenoides elongatus*, *Skwala parallela*, *Claassenia sabulosa*, *Sweltsa borealis*, and *Sweltsa coloradensis*, have been collected in nine provinces or states. By contrast 17 species have been collected in only one or two of the provinces or states respectively. Several of these rarer species are common in other sections of the United States such as *Pteronarcys dorsata*, *Isoperla trictura*, *Acroneuria internata*, and *Perlesta placida*. Others such as *Alloperla pilosa*, *Lednia tumana*, *Capnia spenceri* and *Nemoura arctica* have been taken in only one or two areas.

Of the various sections of the Rocky Mountains collected Glacier National Park has been most productive. Seventy-three species of stoneflies have been collected from the park, including several species which have yet to be described. Specimens have been collected from practically every conceivable aquatic habitat including seeps, ponds, waterfalls, torrential and slow moving streams and lakes. Adults have been taken at all seasons of the year; and, fall, winter, spring and summer emergents have all been collected within the confines of the park from mid-June through mid-August. Species which normally emerge in February and March at lower altitudes, 400 miles southward have been collected emerging in large numbers from snow-fed lakes and streams during midsummer. Eighteen species have been collected from lakes, a habitat which normally supports very few species of stoneflies in other regions of the country. Stoneflies more representative and common to the Pacific Coast, the southern Rockies, the Great Plains, the Arctic, and the high plateaus are intermixed, presenting an unusual diversity of stoneflies and very interesting ecological problems.

PRELIMINARY STUDIES ON PENNSYLVANIA STONEFLIES.

BY REBECCA F. SURDICK, *Department of Entomology, Pennsylvania State University, University Park, Pennsylvania.*

Little work has been done on the taxonomy and natural history of Plecoptera in Pennsylvania. However, numerous mountain watersheds and lowland streams and rivers in the state provide excellent habitat for a varied and abundant stonefly fauna. The present study, involving an examination of various collections and literature records, resulted in a list of 79 species comprising 32 genera. Thus, over half of the genera and nearly half of the species whose geographical range includes the eastern United States were found in Pennsylvania. Identification keys were constructed for the nymphs of the families Perlidae, Perlodidae and Pteronarcidae. The information obtained will facilitate the identification of Plecoptera in taxonomic and ecological studies, pollution investigations and stream surveys and provide a baseline list of species that may be found in Pennsylvania watercourses. More extensive and intensive collecting in the future is expected to yield undescribed species and reveal new state records.

BIOGEOGRAPHY OF NEW ZEALAND PLECOPTERA.

BY IAN D. MCLELLAN, *Westport, New Zealand.*

For a better understanding of the discussion on the possible origins of New Zealand's present stonefly fauna the following summary of its geological and climatic history is given.

New Zealand was a trough in the sea floor adjacent to Australia and Antarctica at the end of the Palaeozoic. The trough became filled in and New Zealand appeared around Late Jurassic–Early Cretaceous. By this time the Tasman Sea was forming and, as drift occurred, the gap became considerable between New Zealand and the rest of Gondwanaland. This drift continued and now New Zealand is 1800 km from Australia and 2500 km from Antarctica. When first formed, New Zealand was mountainous with a temperate climate but by Late Cretaceous the land was eroded to almost sea level and the climate sub-tropical. This low lying land persisted with a sub-tropical–tropical climate until mountain building and cooling of climate occurred in the Miocene. This mountain building is still continuing.

Colonisation by stoneflies by land could have occurred but this would mean isolation for 130 million years with unfavourable conditions from Upper Cretaceous to Upper Miocene. An alternative is arrival by wind drift. In recent years there are many records of Australian insects and birds crossing by this method and successfully invading new biotopes made available by man's activities. This must have occurred in the past when niches became available as topography and climate changed. It has been calculated that suitable drift conditions occur 20–30 days a year, spread throughout the year. How does this fit in with what is known about the New Zealand stoneflies?

First, with the largest group, the gripopterygids, we find a closely related group of genera with a common feature (lack of tibial spurs) not found as such in other gripopterygid groups. Therefore, they must be derived from a single species or group of closely related species. If they arrived 130 million years ago surely there would have been greater differences. This lack of difference could be explained by saying that one species survived the unfavourable conditions until the Upper Miocene when speciation was made possible in more favourable biotopes. If arrival was not by land the most obvious course is by wind drift from Australia from the Upper Miocene onwards. This would account for the close relationship of genera.

The two methods of invasion are also possible for the Antarctoperlinae. However, this subfamily is found only in New Zealand and South America. These two land masses were divided by Antarctica so that it is only possible for them to have arrived via Australia where they must have become extinct at a later time.

The notonemourids can be divided into two groups, the Notonemoura group and the Spaniocerca-Spaniocercoides group. The Notonemoura group has very close relatives in Australia (included in the same genus) and would be a wind drift invader at or after the end of the Pleistocene. The Spaniocerca-Spaniocercoides group consists of forms which differ from their Australian counterparts to a greater degree and are probably pre-Pleistocene.

The remaining two stoneflies *Stenoperla prasina* (Eustheniidae) and *Austroperla cyrene* (Austroperlidae) both have very closely related forms in Australia and are obviously recent invaders by wind drift.

Within New Zealand there is only one endemic found in the North Island but there is considerable endemism in the south with restricted species existing in those areas considered to be Pleistocene refugia. Many of the endemics are found in alpine biotopes. Many of the gripopterygids and antarctoperlinids are wingless and a number of their larvae are terrestrial. The alpine notonemourids have not changed greatly. They have very similar sister species in the lowlands or are forms of lowland species. One point which must be remembered in relation to alpine stoneflies is that New Zealand's alpine biota is not older than Upper Miocene.

A PRELIMINARY REPORT OF THE PLECOPTERA FAUNA IN BOSNIA AND HERZEGOVINA (YUGOSLAVIA).

BY DRAGICA KAĆANSKI, *Bioloski Institut Univerziteta, Sarajevo, Yugoslavia.*

The faunistical survey of Plecoptera from Bosnia and Herzegovina, which according to ILLIES' classification of the European limnofauna (1967) is situated within the limits of the western Balkan region, is based

TABLE 2. List of Plecoptera species. B = drainage area of the river Bosna. D = drainage area of the river Drina. N = drainage area of the river Neretva (middle reaches). L = running waters in southwestern Bosnia (environments of Livno). O = other localities.

	B	D	N	L	O
Taeniopterygidae					
Brachyptera graeca BERTHELEMY	+	+	+		
helenica AUBERT		+	+		
risi (MORTON)	+	+			+
seticornis (KLAPALEK)	+	+			+
tristis (KLAPALEK)	+	+	+	+	+
Taeniopteryx auberti KIS and SOWA	+				
hubaulti AUBERT					+
schoenemundi (MERTENS)		+			
Nemouridae					
Protonemura auberti ILLIES	+	+		+	+
autumnalis RAUSER	+	+			
hrabei RAUSER	+	+			
intricata RIS	+	+	+		+
praecox (MORTON)	+	+			
Amphinemura standfussi RIS	+	+			+
sulcicollis STEPHENS	+	+			+
triangularis RIS	+	+	+		+
Nemoura avicularis MORTON					+
cambrica (STEPHENS)		+			
cinerea (RETZIUS)	+	+		+	+
dubitans MORTON	+				
flexuosa AUBERT	+	+			
fulviceps KLAPALEK	+	+			
marginata PICTET	+	+			+
minima AUBERT	+				
subtilis KLAPALEK		+			
Nemurella picteti KLAPALEK	+	+			
Leuctridae					
Leuctra albida KEMPNY	+	+			
aptera KACANSKI and ZWICK		+			
bronislavi SOWA	+	+			
cinqulata KEMPNY	+	+	+		
digitata KEMPNY	+	+			
fusca (LINNAEUS)	+	+	+		
handlirschi KEMPNY	+	+			
hippopoides KACANSKI and ZWICK	+	+			+
hippopus KEMPNY	+	+			+
hirsuta BOGOESCO and TABACARU	+	+			

TABLE 2. (con't).

	B	D	N	L	O
inermis KEMPNY	+	+			
major BRINCK	+	+			
mortoni KEMPNY	+	+			
nigra (OLIVIER)	+	+			+
olympia AUBERT		+	+		
prima KEMPNY	+	+			
pseudosignifera AUBERT	+	+			
quadrimaculata KIS	+	+			+
rosinae KEMPNY		+			
signifera jahorinensis KACANSKI	+	+			
Capniidae					
Capnia vidua (PICTET)		+			
Capnopsis schilleri (ROSTOCK)	+				
Perlodidae					
Arcynopteryx compacta MACLACHLAN		+			
Besdolus imhoffi (PICTET)					+
Dyctiogenus fontium RIS				+	
Perlodes jurassica AUBERT					+
intricata (PICTET)	+				
microcephala (PICTET)	+	+			+
Isoperla albanica AUBERT	+	+			+
buresi RAUSER	+	+			+
graeca AUBERT	+	+			+
grammatica (PODA)	+				
inermis KACANSKI and ZWICK			+		+
oxylepis (DESPAX)	+	+	+		+
tripartita ILLIES	+	+			
Perlidae					
Dinocras megacephala (KLAPALEK)	+	+	+		
Perla bipunctata PICTET		+			
burmeisteriana CLAASSEN	+	+			+
illiesi BRAASCH and JOOST					+
marginata (PANZER)	+	+	+		+
pallida GUERIN			+		
Chloroperlidae					
Siphonoperla montana (PICTET)	+				+
neglecta (ROSTOCK)	+	+			+
neglecta graeca (AUBERT)		+			
transsylvanica (KIS)	+	+			?+
Chloroperla russevi BRAASCH	+	+			
tripunctata (SCOPOLI)		+	+		+

on material collected since 1958, with the most intensive collecting occurring after 1966.

Adult Plecoptera were collected mostly in the drainages of the Bosna and Drina rivers, in the middle reaches of the Neretva River, in Karst streams of southwestern Bosnia (in the environs of Livno) and from time to time from other localities throughout Bosnia and Herzegovina.

The identification of the collected Plecoptera resulted in 73 species and subspecies (Table 2).

The list of Plecoptera obtained reveals a great variety of zoogeographical elements.

Among the established stoneflies, 3 species (*Leuctra aptera, L. hippopoides, Isoperla inermis*) and a subspecies (*L. signifera jahorinensis*) occur only in the Dinaric ranges.

Five species are found both in the Dinaric ranges and the Carpathian Mountains: *Taeniopteryx auberti, Protonemura autumnalis, Leuctra bronislavi, L. quadrimaculata* and *Siphonoperla transsylvanica.*

Eight species, *Brachyptera graeca, B. helenica, B. tristis, Leuctra olympia, Isoperla albanica, Perla illiesi, Siphonoperla neglecta graeca, Chloroperla russevi,* are restricted to the Balkan region. Four species: *Nemoura subtilis, Leuctra hirsuta, Isoperla buresi* and *I. graeca* occur only in southeastern Europe.

Worthy of note is the finding of 3 species whose center of distribution is the Alps: (*Nemoura minima, Dyctiogenus fontium, Siphonoperla montana*). The bulk of the remaining species (20) are common to Central Europe.

AUTOHEMORRHAGE IN TWO STONEFLIES AND ITS EFFECTIVENESS AS A DEFENSE MECHANISM.

BY ERNEST F. BENFIELD, *Department of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.*

When subjected to traumatizing stimuli, adults of the stoneflies *Pteronarcys proteus* Newman and *Peltoperla maria* Needham and Smith autohemorrhage at the intersegmental membranes of the coxial and tibiofemoral joints of the legs. Autohemorrhage reactions can be somewhat localized when local stimuli are applied, e.g. if one leg is traumatized, bleeding occurs at that leg. However, a more general stimulus, e.g. grasping the animal's trunk, elicits a response at most or all of the legs.

Autohemorrhage in both stoneflies is an effective defensive mechanism against certain ants. In *Pteronarcys,* autohemorrhage is often of an "explosive" nature in that the hemolymph is forcibly expelled with droplets carrying up to 10 inches from the animal. The "explosive autohemorrhage" of *Pteronarcys* is accompanied by an audible popping sound which, in combination with the hemolymph droplets, was shown to delay attack by a vertebrate predator.

ASPECTS OF THE MORPHOLOGY AND FUNCTIONS OF TRACHEAL GILLS OF SOME PLECOPTERAN NYMPHS.

BY NARINDER N. KAPOOR, *Department of Biology, Loyola College, Montreal, Canada.*

Nymphs of some Plecoptera possess cuticular filamentous gills on different parts of the body. These gills occur as lateral tufts on each thoracic segment of the *Paragnetina media*. A closely related species, *Phasganophora capitata* has an additional pair of anal gills. The nymphs of the family Eustheniidae have 5–6 pairs of gills on the abdomen.

Experimental studies showed that *Paragnetina* could not survive without gills and there was a considerable reduction (70–78%) in oxygen uptake when gills were removed (Kapoor 1974a).

The scanning and transmission electron microscope studies revealed fascinating structures and associated cells on the gills. Cuticular discs are distributed profusely on the proximal portion of the gills of *Phasganophora* and *Paragnetina*. A large number of hairs are interspersed among the discs of *Phasganophora*. The disc is part of a highly specialized bag shaped 'Osmoregulatory cell' (Kapoor and Zachariah, 1973; Kapoor 1974b).

On the finger-like abdominal gills of eustheniids are found flower bud-like structures and few cuticular hairs. These structures are probably sensory in function since each structure is associated with a bipolar neuron. Wichard and Komnick (1974) have provided histochemical evidence to show that similar bulbiform structures in the integument of *Protonemura* are probably involved with the absorption of chloride ions.

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NOTES ON THE FAMILY SCOPURIDAE.

BY TEIZI KAWAI, *Zoological Institute, Nara Women's University, Nara, Japan.*

Since the establishment of the family Scopuridae in 1935, it has been considered monospecific with only the remarkable species *Scopura longa*

FIG. 8. Map indicating the geographical distribution of *Scopura longa* Uéno and *Scopura*, n. sp. ●, *Scopura longa*; ○, *Scopura* n. sp. 1. Type-locality of *S. longa*, middle of July, 1925, Towada Lake, by M. Uéno and T. Kawamura. 2. Locality at which male of *S. longa* was found for first time, 28 Sept. 1928, Takeishi Pass, Nagano Pref., by H. Kiyosawa. 3. Locality at which female of *S. longa* was found for first time, 13 July 1936, Hakuun Fall, Nikko, by M. Kohno. 4. Type-locality of *Scopura* n. sp., 12 Nov. 1972, Mt. Myoken, Is. Sado, by S. Uéno.

Uéno, 1929. However, having examined some interesting specimens of *Scopura* from the Island of Sado which lies in the Sea of Japan, circa 45 km from Niigata, I have reached the conclusion that they should be separated from *Scopura longa* as a new species. This new form is to be called *Scopura* n. sp. Its present records of distribution are restricted to the Island of Sado and a portion of the North Kanto District (Ibaragi Pref.).

As far as has been known, more than 350 localities have been reported from Honshu and Hokkaido as well as Korea by Komatsu (1970). All of them are those of *Scopura longa* and most of them are the records of nymphs. The geographical distribution of the imagines of the two species in question is shown in Figure 8. Both species are usually found in cold water streams or the adjacent hygroscopic places where the temperature of the water is lower than 10°C in midsummer. The family seems, therefore, to be a typical boreo-alpine inhabitant, capable of living either in the hygroscopic places such as mosses and fallen leaves or on the wet trunks of trees.

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DISTRIBUTION OF STONEFLIES (PLECOPTERA) WITHIN THE HUBBARD BROOK WATERSHED, NEW HAMPSHIRE.

by Samuel M. Fiance, *Department of Entomology, Cornell University, Ithaca, New York.*

Preliminary distributions of ten species of stoneflies were based on collections during spring and summer of 1974. *Allonarcys biloba*, *Peltoperla maria*, and *Leuctra tenuis* have riverine distributions. The distributions of *Sweltsa lateralis*, *Sweltsa mediana*, *Leuctra tenella*, *Leuctra ferruginea* and *Amphinemura wui* are limited only by the extent of permanently flowing waters. *Leuctra duplicata* and *Ostrocerca albidipennis* were found in temporary as well as permanently flowing waters.

Substrate conditions appear to be correlated with distribution of *Allonarcys biloba* which was found associated with large boulders and swiftly flowing waters.

In addition to the species listed above, *Alloperla chloris*, *Hastaperla brevis*, *Paranemoura perfecta* and *Paracapnia angulata* also were recorded from the Hubbard Brook Watershed. It appears that some of these species are unrecorded from New Hampshire.

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